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RESEARCH ARTICLE

Exploring cattle sheds as complementary avifaunal habitat niches in rice dominated agricultural areas in Punjab, India

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ABSTRACT

Avian diversity has often been studied in agricultural habitats, but ornithological aspect of cattle sheds has never been studied. This exploratory study was conducted with the objective of studying the potential of cattle sheds for sustaining avian abundance and diversity in rice dominated agricultural areas. The study was done in Rice Field Ecosystem (System I) and Cattle Shed Ecosystem (System II) during 2019 and 2020 monsoon crop season from selected villages, namely, Dangon, Pakhowal and Sarabha (district Ludhiana), Punjab. It was recorded that 26 avian species (mainly of grassland habitat) were present in cattle sheds from a total 34 avian species (wetland, grassland and open countryside inhabiting species) observed in rice fields, which reflected that cattle sheds support a wide proportion of avian fauna and complement rice fields in supporting and preserving avian abundance and diversity. There is immense need toexplore and accordingly lay emphasis on boosting dairy as allied sector so that cattle sheds can be exploited in preservation of diverse avian populations and thereby reinforcing approach of sustainable agriculture.

Keywords: Avian diversity; Avian feeding guilds; Cattle Shed; Grassland birds; Rice crop

INTRODUCTION

Agro-ecosystems provide a natural habitat to native animals for food, shelter, reproduction and other activities. Birds are diverse consumers that occupy either the secondary or the topmost trophic level of the ecosystem. The role of birds is evident in the agricultural landscape as it supplies highly predictable and concentrated food source. Rice fields provide feeding and nursery grounds for various bird species; acting as a unique wetland in the ecosystem (Mojiol et al., 2008; Mohd-Taib and Kamaruddin, 2018). Due to the degradation or complete disappearance of natural wetlands for last few decades, rice fields act as temporary wetland habitat for many waterbirds (Kumar et al., 2021). The area under cultivation of rice supports more than 350 species of birds throughout India (Gopisundar and Subramanya, 2010). Avifauna is, of course, under evident vulnerability as result of intense anthropogenic activities which further results in habitat shifting, and affecting avian classes to varying extent (Harisha et al., 2021).

Rice cultivation is an important food source for about 40% of world's population (Kumar et al., 2021). India produces more than 20% of the total rice production under an area of 3.80 million hectares, thus acts as an agrarian economy (Agristat, 2016; Jayasimhan and Pramod, 2019), and the second largest producer in terms of global rice production. Punjab is a North- West state of India having 81.82% net sown area out of 5033 thousand hectares of the total geographical area. Rice is cultivated in 75.35% of the net sown area. The area under rice cultivation in Ludhiana district is 259 thousand hectares which produce 1721 thousand tonnes of rice and the yield is 6646 kg/ha (Anonymous, 2021).

Punjab has 25.31 lakh cows, 40.16 lakh buffaloes, which constitute 92.8% of the total livestock (Anonymous 2019).

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Livestock production in Punjab generated 8.4% of the Net State Domestic Product (NSDP). Livestock's percentage contribution to agriculture's GDP increased from 28.5% in 1990-1991 to 29.6% in 2010-2011 (Anonymous, 2014).

Neither research on the ornithological aspects of cattle sheds has been carried out nor has the literature been published from the farmlands of Indo-Gangetic plains. The present work has been conceptualized and conducted with the following objectives.

a.) Assessment of bird diversity in rice fields and cattle sheds of district Ludhiana, Punjab. b.) Understanding the role of cattle sheds as alternative avifauna foraging niches in rice dominated agricultural areas of Ludhiana district in Punjab.

MATERIALS AND METHODS

Study Area

The present study on avifauna was undertaken in two consecutive monsoon crop seasons, 2019 and 2020. Three villages, namely, Dangon, Pakhowal and Sarabha in district Ludhiana, Punjab were selected. Our study was based on one rice field (4047 m^2) and one cattle shed (70x 90 ft approx.) from each selected village. The three rice fields laid at 30°43'27.0"N 75°43'14.6"E, 30°42'08.2"N 75°42'13.1"E and 30°44'38.4"N 75°42'01.4"E. There were electricity poles and wires. An unplastered storage/ operational room was also present where agricultural tools were kept. A submersible motor and cemented water tank were present near the storage room. Tree diversity included Arjun (*Terminalia arjuna*), Dharek (*Melia azedarach*), Guava (*Psidium guajava*), Jamun (*Syzygium cumini*), Kikar (*Acacia Nilotica*), Neem (*Azadirachta*), Peepal (*Ficus religiosa*), Banyan (*Ficus*) and Safeda (*Eucalyptus*). The studied cattle sheds laid at 30°43'12.9"N 75°42'58.4"E, 30°42'28.2"N 75°42'25.8"E and 30°44'58.5"N 75°42'16.1"E. The cattle sheds were having unplastered walls, brick lined flooring and were supported with pillars, with well ventilation and electrical facilities. The shed consisted of storage rooms where dry feed, green fodder, fodder chopping machine and other materials were kept. Shed structure was also having barn yard in each cattle shed to keep the cattle under shade of trees, especially in summer. Tree diversity varied in each cattle shed and the species present were Dharek (*Melia azedarach*), Kikar (*Acacia Nilotica*), Neem (*Azadirachta*), Peepal (*Ficus religiosa*) and Silver Oak (*Grevillea robusta*).

Survey methods

Line and point transect methods were used for surveying diverse species of birds (Verner, 1985). The bird species from rice fields were recorded during each agronomic activity. During the vegetative growth and grain formation, observations were recorded twice a week, 2 hours each in the morning and evening. The observations from the cattle sheds were taken twice a week (on alternate days with rice fields), 2 hours each in the morning and evening. Birds were identified and grouped based on their feeding habits as described by Ali (2002). The checklist of species was prepared following the nomenclature of Praveen et al. (2016).

For the study purpose, agronomical practices and phenological stages of rice crop have been considered under 3 major headings: Field preparations (ploughing, manuring, flooding and ploughing), Growth stages (transplanting, vegetative stage, grain formation or milky stage) and Mature stage (ripening, harvesting and then post-harvesting). In the present communication, Rice Field Ecosystem (RFE) and Cattle Shed Ecosystem (CSE) have been taken as System I and System II respectively. Ploughing stage has been abbreviated as RS 1, manuring as RS 2, flooding and ploughing as RS 3, transplanting as RS 4, vegetative stage as RS 5, grain formation or milky stage as RS 6, ripening as RS 7, harvesting as RS 8 and post-harvesting as RS 9.

Instruments used

A Bushnell binocular ranging as 7x50 was used for observing avian diversity. The photography part was accomplished using Canon EOS 1300D (18 MP, Digital SLR) camera having EF S18-55mm and EF S55-250mm lens.

Statistical analysis

From the pooled data of different bird species visiting/ inhabiting RFE and CSE, values of Relative abundance were calculated. Relative abundance (%) was calculated as: (ni/N) x 100, where ni is the number of birds of ith species and N is the total number of birds of all species. Species diversity (H) and Species evenness (J) were calculated from bird abundance data (Krebs et al., 1985). Statistical method of Independent t-test was performed to find the significant difference between species richness of System I and II; t-test for equality of means was done to test the significant difference between abundance of avian diversity at System I and II.

RESULTS AND DISCUSSION

In System I, species richness ranged from 26 to 34 during different growth stages of rice crop; while it ranged from 20 to 26 in System II corresponding to that period. Avian species belonging to 31 genera under 13 orders and 26 families were recorded. A complete checklist of avian species

recorded during the study has been given in Table 1. On the basis of independent t-test there was significant difference between System I and System II with p value of $1.69x10^{-6}$.

Seven species were exclusively recorded at RFE, while 27 species were found to be common to System I and System II. No species was recorded exclusively at System II (Table 1). The abundance of each species observed during the studied period at RFE and CSE was compared using t-test for equality of means (Table 2). The rice fields inundated with irrigation water seemed to act as temporary wetland habitats which supported rich abundance of wetland preferring or water dependent avian species like Black-headed Ibis, Glossy Ibis, Red-naped Ibis and White-breasted Waterhen. Presence of Banyan tree in RFE supported canopy dwellers like Yellow-footed Green Pigeon. Kler and Parshad (2011) recorded about 32 bird species in rice cultivated areas in Punjab.

Field preparations

RS 1: Ploughing Stage:- At RS 1, a total of 32 and 22 species were recorded from RFE and CSE respectively. Out of these 9 species showed a significant difference in abundance between the two systems. Bank Myna and Red-wattled Lapwing were significantly higher in abundance at RFE (Table 3). This variation was due to better food availability (invertebrates, insects) during the process of ploughing. Seven species were significantly higher in abundance at CSE (Table 3). Stafford et al. (2010) reported the presence of birds in the rice fields was mainly due to human activities, such as ploughing as it attracted many kinds of bird species for foraging and roosting.

Table 1: Complete checklist of avian species recorded during the study with respective order, family, residential status, feeding guild and IUCN Status

S.No.	Species	Scientific name	Order	Family	Residential Status	Feeding Guild	IUCN Status
1.	Alexandrine Parakeet	*Psittaculaeupatria*	Psittaciformes	Psittacidae	R	F	LC
2.	Asian Koel	*Eudynamysscolopacea*	Cuculiformes	Cuculidae	R	O	LC
3.	Bank Myna	*Acridotheresginginianus*	Passeriformes	Sturnidae	R	O	LC
4.	Black Drongo	*Dicrurusmacrocercus*	Passeriformes	Dicruridae	R	I	LC
5.	Black Francolin*	*Francolinusfrancolinus*	Galliformes	Phasianidae	R	O	LC
6.	Black-headed Ibis*	*Threskiornismelanocephalus*	Pelecaniformes	Threskiornithidae	R	C	NT
7.	Brown Rock Chat	*Oenanthefusca*	Passeriformes	Muscicapidae	R	I	LC
8.	Cattle Egret	*Bubulcus ibis*	Pelecaniformes	Ardeidae	R	C	LC
9.	Common Hoopoe	*Upupaepops*	Bucerotiformes	Upupidae	RM	I	LC
10.	Common Myna	*Acridotherestristis*	Passeriformes	Sturnidae	R	O	LC
11.	Common Tailorbird	*Orthotomussutorius*	Passeriformes	Cisticolidae	R	I	LC
12.	Coppersmith Barbet	*Psilopogonhaemacephalus*	Piciformes	Ramphastidae	R	F	LC
13.	Eurasian Collared Dove	*Streptopeliadecaocto*	Columbiformes	Columbidae	R	G	LC
14.	Glossy Ibis*	*Plegadisfalcinellus*	Pelecaniformes	Threskiornithidae	RM	C	LC
15.	Greater Coucal	*Centropussinensis*	Cuculiformes	Cuculidae	RM	C	LC
16.	Green Bee-Eater	*Meropsorientalis*	Coraciiformes	Meropidae	R	I	LC
17.	Grey Francolin*	*Francolinuspondicerianus*	Galliformes	Phasianidae	R	O	LC
18.	House Crow	*Corvussplendens*	Passeriformes	Corvidae	R	O	LC
19.	House Sparrow	*Passer domesticus*	Passeriformes	Passeridae	R	O	LC
20.	Indian Grey Hornbill	*Ocycerosbirostris*	Bucerotiformes	Bucerotidae	R	O	LC
21.	Jungle Babbler	*Turdoidesstriatus*	Passeriformes	Leiothrichidae	R	O	LC
22.	Little Egret	*Egrettagarzetta*	Pelecaniformes	Ardeidae	R	C	LC
23.	Paddyfield Pipit	*Anthusrufulus*	Passeriformes	Motacillidae	R	I	LC
24.	Purple Sunbird	*Cinnyrisasiaticus*	Passeriformes	Nectariniidae	R	N	LC
25.	Red-vented Bulbul	*Pycnonotuscafer*	Passeriformes	Pycnonotidae	R	I	LC
26.	Red-naped Ibis*	*Pseudibispapillosa*	Pelecaniformes	Threskiornithidae	R	C	LC
27.	Red-wattled Lapwing	*Vanellusindicus*	Charadriiformes	Charadriidae	R	I	LC
28.	Rock Pigeon	*Columba livia*	Columbiformes	Columbidae	R	G	LC
29.	Rose-ringed Parakeet	*Psittaculakrameri*	Psittaciformes	Psittaculidae	R	F	LC
30.	Shikra	*Accipiter badius*	Accipitriformes	Accipitridae	R	C	LC
31.	Spotted Owlet	*Athene brama*	Strigiformes	Strigidae	R	I	LC
32.	White-breasted Waterhen*	*Amaurornisphoenicurus*	Gruiformes	Rallidae	R	I, P	LC
33.	White-throated Kingfisher	*Halcyon smyrnensis*	Coraciiformes	Alcedinidae	R	C	LC
34.	Yellow-footed Green Pigeon*	*Treronphoenicopterus*	Columbiformes	Columbidae	R	F	LC

R: Resident; RM: Resident Migrant; O: Omnivores; I: Insectivores; C: Carnivores; F: Frugivores; G: Grainivores; N: Nectarivores; P: Plants; LC: Least Concerned; NT: Near Threatened
*species exclusively observed at System I

Table 2: Comparison of System I and System II using t test for equality of means at different stages giving t-value and significant level value. Highlighted cells depict the significant difference in avian species abundance between both the Systems.

Stage	RS 1		RS 2		RS 3		RS 4		RS 5	
	t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means	
Species	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**
Alexandrine Parakeet	-	-	-	-	0.486	0.653	-	-	0.292	0.782
Asian Koel	-2.252	0.087	-	-	-8.402	0.001	-	-	-1.093	0.316
Bank Myna	3.371	0.015	4.438	0.004	5.384	0.003	3.539	0.012	2.724	0.034
Black Drongo	0.423	0.687	-0.790	0.465	1.466	0.193	-0.402	0.701	1.334	0.231
Black Francolin	-	-	-	-	-	-	-	-	-	-
Black-headed Ibis	-	-	-	-	-	-	-	-	-	-
Brown Rock Chat	-1.114	0.316	-1.332	0.254	-2.832	0.037	4.464	0.140	-2.246	0.066
Cattle Egret	0.697	0.512	-0.526	0.618	3.136	0.020	-1.515	0.180	1.041	0.338
Common Hoopoe	-0.813	0.453	-1.553	0.172	-0.225	0.831	-0.235	0.823	0.609	0.565
Common Myna	-1.773	0.127	-4.073	0.007	-3.710	0.010	-1.697	0.141	-2.747	0.033
Common Tailorbird	-2.965	0.031	-2.559	0.043	-2.806	0.038	-5.770	0.004	-1.804	0.121
Coppersmith Barbet	-8.881	0.071	-5.589	0.011	-45.638	0.000	-0.338	0.767	-1.906	0.153
Eurasian Collared Dove	-3.628	0.011	-7.573	0.000	-10.628	0.000	-11.724	0.000	-8.627	0.000
Glossy Ibis	-	-	-	-	-	-	-	-	-	-
Greater Coucal	1.822	0.210	0.847	0.445	-0.540	0.618	0.519	0.631	-1.027	0.351
Green Bee-eater	-0.192	0.857	-	-	0.410	0.703	0.661	0.538	1.413	0.207
Grey Francolin	-	-	-	-	-	-	-	-	-	-
House Crow	-1.634	0.153	-6.983	0.000	-4.278	0.005	-4.087	0.009	-0.953	0.377
House Sparrow	-6.314	0.001	-4.065	0.010	-8.667	0.000	-9.679	0.000	-4.927	0.003
Indian Grey Hornbill	-	-	-1.946	0.147	2.797	0.038	-0.727	0.500	0.613	0.562
Jungle Babbler	-0.640	0.568	-2.278	0.107	-2.891	0.045	-	-	-2.234	0.076
Little Egret	-	-	-	-	-	-	-	-	0.294	0.783
Paddyfield Pipit	-	-	-	-	-	-	-	-	0.298	0.785
Purple Sunbird	-2.758	0.040	-0.846	0.436	-2.110	0.079	-2.353	0.065	-3.291	0.017
Red-naped Ibis	-	-	-	-	-	-	-	-	-	-
Red-vented Bulbul	-3.694	0.010	-2.484	0.048	-7.298	0.000	-2.353	0.065	-1.550	0.172
Red-wattled Lapwing	7.964	0.000	3.547	0.016	4.768	0.005	3.146	0.025	9.935	0.000
Rock Pigeon	-3.921	0.008	-4.703	0.003	-8.408	0.000	-5.313	0.002	-4.888	0.003
Rose-ringed Parakeet	-3.038	0.023	-0.739	0.493	-3.137	0.026	-3.754	0.013	-2.728	0.034
Shikra	-0.636	0.559	-3.564	0.038	-108.516	0.006	-0.783	0.469	2.059	0.132
Spotted Owlet	-	-	-0.349	0.744	-	-	-	-	-	-
White-breasted Waterhen	-	-	-	-	-	-	-	-	-	-
White-throated Kingfisher	0.066	0.951	-0.051	0.961	-0.462	0.663	1.577	0.190	3.007	0.024
Yellow-footed Green Pigeon	-	-	-	-	-	-	-	-	-	-

Stage	RS 6		RS 7		RS 8		RS 9	
	t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means	
Species	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**
Alexandrine Parakeet	-	-	-3.760	0.033	-0.231	0.827	-2.338	0.067
Asian Koel	-	-	-2.729	0.052	-7.148	0.002	-1.279	0.270
Bank Myna	7.521	0.000	4.018	0.007	2.617	0.047	11.927	0.000
Black Drongo	0.908	0.399	0.867	0.419	0.044	0.966	0.936	0.386
Black Francolin	-	-	-	-	-	-	-	-
Black-headed Ibis	-	-	-	-	-	-	-	-
Brown Rock Chat	0.065	0.952			-2.518	0.086	-	-
Cattle Egret	0.428	0.684	-0.382	0.715	0.118	0.910	0.665	0.531
Common Hoopoe	-1.796	0.132	-0.384	0.717	-1.085	0.327	-0.614	0.566

(*Contd...*)

Table 2: (*Continued*)

Stage	RS 6		RS 7		RS 8		RS 9	
	t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means		t-test for Equality of Means	
Species	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**	**t**	**Sig. (2-tailed)**
Common Myna	-1.742	0.132	-3.807	0.009	-2.810	0.031	-4.902	0.003
Common Tailorbird	-2.883	0.034	-2.222	0.068	-6.999	0.001	-3.637	0.015
Coppersmith Barbet	-1.490	0.275	-1.811	0.212	-1.766	0.219	-0.122	0.914
Eurasian Collared Dove	-7.226	0.001	-3.669	0.010	-5.191	0.002	-3.405	0.014
Glossy Ibis	-	-	-	-	-	-	-	-
Greater Coucal	-0.692	0.539	0.249	0.815	-0.231	0.832	-0.203	0.849
Green Bee-eater	0.361	0.733	1.178	0.304	-	-	-1.356	0.233
Grey Francolin	-	-	-	-	-	-	-	-
House Crow	-2.748	0.033	-2.827	0.030	-2.795	0.038	-5.003	0.002
House Sparrow	-6.303	0.001	-3.036	0.039	-9.134	0.000	-2.911	0.044
Indian Grey Hornbill	-1.177	0.284	-4.236	0.008	0.235	0.824	-1.927	0.112
Jungle Babbler	-0.057	0.957	-6.294	0.008	-	-	-2.633	0.046
Little Egret	-	-	-	-	-	-	-	-
Paddyfield Pipit	0.283	0.796	-	-	-	-	-	-
Purple Sunbird	-3.918	0.008	-0.821	0.443	-1.281	0.256	-2.961	0.042
Red-naped Ibis	-	-	-	-	-	-	-	-
Red-vented Bulbul	-3.710	0.010	-1.626	0.155	-5.237	0.002	-7.894	0.001
Red-wattled Lapwing	3.814	0.009	2.635	0.046	1.525	0.202	4.275	0.005
Rock Pigeon	-4.912	0.003	-4.765	0.003	-3.392	0.015	-4.859	0.003
Rose-ringed Parakeet	-1.582	0.175	-1.335	0.239	-3.630	0.015	-1.063	0.336
Shikra	-1.601	0.170	-	-	-0.501	0.638	-	-
Spotted Owlet	-	-	-	-	-	-	-	-
White-breasted Waterhen	-	-	-	-	-	-	-	-
White-throated Kingfisher	0.049	0.964	-1.332	0.254	0.544	0.624	-0.504	0.641
Yellow-footed Green Pigeon	-	-	-	-	-	-	-	-

RS 2: Manuring Stage:- At RS 2, the species richness was observed to be 27 at RFE and 21 at CSE corresponding to that period. Out of these, the abundance of 11 species varied significantly in abundance. As had been noted in RS 1, Bank Myna and Red-wattled Lapwing were also found significantly higher in abundance at RFE during RS 2 (Table 3). Invertebrates in the Farm Yard Manure (FYM) seemed to be the reason for the said observation. Nine species were observed to be significantly higher in abundance at CSE (Table 3). Selected CSEs had good population of squirrels (varied from 9 to 16) and were not having structural rodent proofing. Visual encounters of rats as well as fecal matter of rodents have been observed in the CSE. Presence of rodents seemed to attract carnivores birds like Shikra. Rana et al. (2020) had reported that Shikra fed on various insects, rodents, squirrels, small reptiles and birds.

RS 3: Flooding and Ploughing:- At RS 3, seventeen species showed significant difference in abundance at studied Systems from a total of 34 and 24 species observed at RFE and CSE respectively. Four species were observed significantly higher in abundance at RFE (Table 3), as invertebrates and insects were abundant during the process of flooding and ploughing. Abundance of thirteen species was significantly higher at CSE (Table 3). Shikra was observed feeding on rodents and hatchlings of other species (House Sparrow and Red-vented Bulbul) that nested in the cattle sheds. Stafford et al. (2010) reported that seasonal flooding in fields attracted many kinds of bird species for foraging and roosting.

Growth stages

RS 4: Transplanting:- After RS 3, nursery transplantation was carried out in the flooded fields. At this stage 26 and 21 species were recorded at RFE and CSE respectively. Out of these, 8 species showed significant difference in abundance between both systems. Similar to RS 1, RS 2 and RS 3, Bank Myna and Red-wattled Lapwing were observed significantly higher in abundance at RFE during RS 4 also (Table 3) due to availability of invertebrates and insects in the puddled fields. Six species were observed to be significantly higher in abundance at CSE (Table 3). The flooded rice fields act as temporary wetlands for avian species. Zakaria and Rajpar

Table 3: Stage-wise mean abundance±standard deviation (%) of avian species which varied significantly between System I and II. Highlighted cells showed the system having higher mean abundance.

Stage	RS 1		RS 2		RS 3		RS 4		RS 5	
System	RFE	CSE	RFE	CSE	RFE	CSE	RFE	CSE	RFE	CSE
Alexandrine Parakeet	-	-	-	-	-	-	-	-	-	-
Asian Koel	-	-	-	-	1.92±0.22	3.92	-	-	-	-
Bank Myna	10.75±1.18	4.68±3.94	8.10±1.71	3.57±0.18	13.17±2.32	3.81±0.15	7.88±2.77	1.89±0.87	10.38±4.71	2.73±0.19
Brown Rock Chat	-	-	-	-	1.56±0.58	3.20±1.03	-	-	-	-
Cattle Egret	-	-	-	-	16.08±2.22	9.72±3.64	-	-	-	-
Common Myna	-	-	7.26±2.85	14.24±0.58	7.87±1.78	14.21±2.17	-	-	8.86±2.38	12.95±1.09
Common Tailorbird	1.71±0.43	3.21±1.05	1.82±0.68	3.76±1.53	1.53±0.60	3.13±0.94	2.33±0.38	4.18±0.33	-	-
Coppersmith Barbet	-	-	0.96±0.21	2.25	0.51±0.01	1.25±0.02	-	-	-	-
Eurasian Collared Dove	1.52±0.20	5.59±2.64	1.97±0.79	5.75±0.38	1.51±0.71	7.19±0.78	1.87±0.77	7.50±0.35	1.69±0.51	4.46±0.22
House Crow	-	-	6.67±2.24	16.05±0.32	5.11±2.23	13.35±3.31	6.05±3.85	15.53±0.92	-	-
House Sparrow	1.32±0.38	4.19±0.93	1.55±0.59	4.18±1.12	0.65±0.25	4.88±1.10	1.60±0.34	4.67±0.51	1.22±0.76	3.45±0.06
Indian Grey Hornbill	-	-	-	-	1.81±0.27	1.25±0.02	-	-	-	-
Jungle Babbler	-	-	-	-	1.27±0.77	3.70	-	-	-	-
Purple Sunbird	1.91±0.35	2.90±0.61	-	-	2.49±0.82	6.13±0.23	-	-	1.69±0.62	3.32±0.78
Red-vented Bulbul	2.00±1.54	5.64±0.85	2.69±1.50	4.96±0.48	-	-	-	-	-	-
Red-wattled Lapwing	7.69±1.09	2.30±0.44	7.24±1.59	2.92±0.64	7.32±1.08	3.13±0.94	9.99±2.69	3.49±1.21	7.75±0.74	2.86±0.53
Rock Pigeon	8.52±2.56	15.14±1.72	8.02±2.90	18.24±3.12	3.86±1.36	15.04±2.50	6.31±2.45	15.58±2.27	6.45±3.43	17.28±2.02
Rose-ringed Parakeet	2.86±0.94	5.78±1.84	-	-	2.58±1.26	6.27±1.88	3.15±1.09	6.85±1.48	2.58±1.35	5.01±0.92
Shikra	-	-	0.66±0.12	1.12	0.51±0.01	1.27	-	-	-	-
White-throated Kingfisher	-	-	-	-	-	-	-	-	1.92±0.50	1.01±0.16

Stage	RS 6		RS 7		RS 8		RS 9	
System	RFE	CSE	RFE	CSE	RFE	CSE	RFE	CSE
Alexandrine Parakeet	-	-	1.55±0.51	3.70	-	-	-	-
Asian Koel	-	-	-	-	1.36±0.33	3.92	-	-
Bank Myna	12.28±2.08	2.96±0.07	8.54±2.50	2.38±0.86	8.90±3.06	2.67±1.78	9.36±0.89	2.75±0.39
Brown Rock Chat	-	-	-	-	-	-	-	-
Cattle Egret	-	-	-	-	-	-	-	-
Common Myna	-	-	7.73±2.84	15.67±2.70	8.55±3.42	16.25±4.33	4.81±1.59	13.25±3.41
Common Tailorbird	1.95±0.48	2.99±0.06	-	-	1.79±0.40	4.01±0.30	1.64±0.42	3.19±0.71
Coppersmith Barbet	-	-	-	-	-	-	-	-
Eurasian Collared Dove	1.54±0.35	6.15±1.55	1.78±0.88	5.98±2.42	1.77±0.58	6.13±1.82	2.11±0.81	5.70±2.22
House Crow	7.45±4.52	14.93±0.92	7.04±2.32	13.24±4.03	6.59±5.10	15.22±1.38	4.18±1.43	12.17±3.20
House Sparrow	1.20±0.47	3.93±0.78	1.52±0.37	3.36±0.98	1.27±0.37	5.06±0.83	1.20±0.29	3.62±1.41
Indian Grey Hornbill	-	-	0.97±0.52	2.51±0.41	-	-	-	-
Jungle Babbler	-	-	2.17±0.09	3.45±0.36	-	-	2.43±0.49	3.45±0.36
Purple Sunbird	1.91±0.45	2.96±0.07	-	-	-	-	1.72±0.48	3.19±0.71
Red-vented Bulbul	2.64±1.48	5.91±0.13	-	-	2.10±1.21	5.95±0.35	1.50±0.14	5.21±0.96
Red-wattled Lapwing	7.32±1.38	3.93±0.78	8.66±2.20	3.89±2.02	-	-	6.51±0.19	3.89±1.43
Rock Pigeon	5.79±3.80	17.41±1.60	8.23±3.19	17.32±0.31	7.09±2.94	14.33±2.88	8.25±2.48	16.20±1.66
Rose-ringed Parakeet	-	-	-	-	3.43±0.94	6.61±1.39	-	-
Shikra	-	-	-	-	-	-	-	-
White-throated Kingfisher		-	-	-	-	-	-	-

(2013) mentioned that the water birds depend entirely on diverse wetlands for performing their daily activities like foraging, nesting, loafing, moulting, etc. On the contrary, terrestrial birds visit such areas for food, shelter and also for foraging purposes.

RS 5: Vegetative Growth:- The vegetative growth continued for about 2 months. At RS 5, 34 and 26 species were recorded at RFE and CSE respectively, out of which 9 species varied significantly in abundance between System I and System II. Three species were observed in significantly higher abundance at RFE (Table 3). It was related to food availability for insectivores species in the rice fields (wetland like ecosystem). Six species were significantly higher in abundance at CSE (Table 3). Sightings of small prey near the water surface lured birds to feed (Acosta

et al., 2010). Nests of Red-wattled Lapwing were found in ploughed field and areas near to water bodies by Sohi and Kler (2017). Pannu and Kler (2018) recorded House Sparrow pairs which constructed nests in the residential areas and reared their chicks in June- July. The insectivore birds were found in abundance in rice fields comprising Cattle Egret, White-throated Kingfisher and Bank Myna among others which foraged upon beetles, ants and other insect (Nyffeler et al., 2018).

RS 6: Grain Formation Stage:-At RS 6, nine species varied significantly from a total of 33 and 23 species observed at RFE and CSE respectively. Bank Myna and Red-wattled Lapwing were significantly higher in abundance at RFE. Abundance of seven species was significantly higher at the cattle sheds (Table 3).

Mature stage

RS 7: Ripening Stage:- Species richness of 29 was at RFE at RS 7 and corresponding to that period species richness of 22 was observed in CSE. Out of these, ten species varied significantly in abundance between System I and II. As already pointed out in all the previous stages (RS 1 to RS 6) Bank Myna and Red-wattled Lapwing were significantly higher in abundance at RFE during RS 7 also (Table 3), which was related to both soil arthropods and rice crop insect pests. Abundance of 8 species was significantly higher at CSE (Table 3). Common Myna, House Sparrow and Jungle Babbler were noted gleaning in cattle dung for larvae/insects. Insectivores birds foraged upon insects present in maize silage utilized as cattle feed. Sridhara et al. (1983) reported that Myna feed on insect pests of rice to a far greater extent than other species.

RS 8: Harvesting:- At RF 8, a total of 26 and 20 species were observed at System I and System II respectively. Out of these, 10 species showed significant difference in abundance between System I and II. Bank Myna was found to be significantly higher in abundance at RFE (Table 3). Abundance of 9 species was observed to be significantly higher at CSE (Table 3). Common Myna and House Crow foraged on invertebrates/insects in fodder, cattle dung and residual food at the cattle sheds.

RS 9: Post-harvesting:- Eleven species varied significantly from a total of 28 and 22 species recorded during the post-harvesting operations at RFE and CSE respectively. Abundance of 2 species was significantly higher at RFE; while 9 species were significantly higher in abundance at CSE (Table 3).

Abundance of Bank Myna was observed to be significantly higher at RFE throughout the study period while that of Red-wattled Lapwing was significantly higher during RS 1 to RS 7 and RS 9 (Table 3). Significantly higher abundance of Eurasian Collared Dove, House Sparrow and Rock Pigeon was observed throughout the study period at CSE (Table 3). Abundance of Common Myna was significantly higher at CSE during RS 2, RS 3, RS 5, RS 7, RS 8 and RS 9, while that of Common Tailorbird was significantly higher at CSE throughout the study period except during RS 5 and RS 7. House Crow was significantly higher in abundance at CSE during RS 2, RS 3, RS 4, RS 6, RS 7, RS 8 and RS 9 (Table 3). Granivores species like Eurasian Collared Dove and Rock Pigeon were observed to feed on the stored grains at the cattle sheds. Nests of House Sparrow, Red-vented Bulbul and Rock Pigeon were recorded in the selected cattle sheds.

The anthropogenic factors contribute in altering the habitat type of cropland birds which tends to approach sheds in cattle farms (Musitelli et al., 2016). The usage of cattle sheds with high-energy feeds like grains and cottonseed that are piled high for easy access by loaders has expanded as dairy production has become more intensive. For corn silage and haylage, tarped, open-face bunker silos have virtually replaced enclosed, upright silos. Foraging birds have easier access attributable to their more recent feed storage techniques (Elser et al., 2019). According to Monika (2005) population of House Sparrows was found to be more in the agricultural areas than in the rural areas. Carlson et al. (2011) reported that livestock facilities were more utilized by Rock Pigeon because of the availability and consistent supply of highly nutritious sources of food as compared to other feeding sites. Dhandhukia and Patel (2012) have reported the nesting of Common Myna on tress, roofs, holes found in the walls of cattle barns. Anthal and Sahi (2013) reported that insectivore species like Jungle Babbler and Common Myna feed on insects (ants, grasshoppers, bees, wasps, beetles, cockroaches, moths, termites, crickets, flies, spiders, caterpillars) from the cattle sheds. Cattle sheds were also reported to support the nesting of House Sparrow (Singh and Kler, 2015) and Rock Pigeon (Sohi and Kler, 2017).

Avian species observed common in System I and II far outnumbered the species observed exclusively at System I. The species richness exclusive to system I ranged from 8-13 at different agronomic and phenological stages, being minimum (8) during the RS 5 and maximum (13) during RS 4 (Table 4). The species exclusively observed in system I during RS 5 were Black Francolin, Black-headed Ibis, Glossy Ibis, Grey Francolin, Red-naped Ibis, Spotted Owlet, White-breasted Waterhen and Yellow-footed Green Pigeon. Out of these species, Black-headed Ibis, Glossy Ibis and Red-naped Ibis have peculiar behavior of inhabiting open countryside areas which are away from human habitation. Rajesh (2016) observed that ibises prefered to

Table 4: Stage-wise feeding guilds of avian species observed common to System I and II and exclusively in System I

Stage	Species common to System I and II		Species exclusive in System I	
	Species Richness	Feeding Guild	Species Richness	Feeding Guild
RS 1	22	6O, 7I, 4C, 2F, 2G, 1N	12	3O, 3I, 4C, 2F
RS 2	22	6O, 7I, 4C, 2F, 2G, 1N	12	3O, 3I, 4C, 2F
RS 3	24	7O, 7I, 4C, 3F, 2G, 1N	10	2O, 3I, 4C, 1F
RS 4	21	5O, 7I, 4C, 2F, 2G, 1N	13	4O, 3I, 4C, 2F
RS 5	26	7O, 8I, 5C, 3F, 2G, 1N	8	2O, 2I, 3C, 1F
RS 6	23	6O, 8I, 4C, 2F, 2G, 1N	11	3O, 2I, 4C, 2F
RS 7	22	7O, 6I, 3C, 3F, 2G, 1N	12	2O, 4I, 5C, 1F
RS 8	22	6O, 6I, 4C, 3F, 2G, 1N	12	3O, 4I, 4C, 1F
RS 9	22	7O, 6I, 3C, 3F, 2G, 1N	12	2O, 4I, 5C, 1F

O: Omnivores; I: Insectivores; C: Carnivores; F: Frugivores; G: Grainivores; N: Nectarivores

live near water bodies or in the irrigated fields because of presence of different type of insects, reptiles and other small invertebrates to feed upon. Soni et al. (2010) observed ibises feeding on beetles, snails, animal matter, insects and organic matter. In present study, Black Francolin and Grey Francolin preferred to inhabit System I exclusively because it acted as natural sheltering grounds and fulfilled cover requirements. Yellow-footed Green Pigeon inhabited System I exclusively due to presence of Banyan (*Ficus*) tree as it feeds on its fruit. So, System II proved to be as good as open fields in supporting 26 commonly noted avian species corresponding to System I. As observed, System II provided alternative foraging site corresponding to RS 5, which seemed to reduce the exclusively observed species in System I. Avian species which chose system II as an alternative feeding site during RS 5 because their foraging requirements could not be fulfilled in the vegetative growth stage of crop. Study findings have established rice crop as valuable habitat for avian abundance and diversity and it further reflected phenological stage specific variations in avian composition. From analysis, it has become evident that RFE supported birds of mainly two habitat groups, viz., wetlands and grasslands and minor groups of canopy dwellers also flourished in it; while CSE were found inhabited chiefly by grassland preferring species. Another emerging point of the present study was that cattle sheds were utilized as avian foraging grounds even during lean periods between successive winter and summer cropping season. It was inferred that regardless of vast differences in their sizes, System I and II seemed complementary to each other in sustaining avian fauna of different feeding guilds belonging to grassland habitat.

CONCLUSION

It has been recorded for the first time that cattle sheds support a vast avian diversity (76.47% of total observed species of rice field ecosystem) due to their structural design, year- round availability of food source (chiefly grains and insects abounding in fodder/silage) for different foraging niches of avian fauna and in addition provided safe cover. It could be emphasized that cattle sheds under dairy development programs may play dual role i.e., as an additional income source for farmers as well as providing point scale conservation sites by sustaining varied avian diversity and enhancing one component of habitat heterogeneity. Even though these are localized observations, but these results can be extrapolated to agricultural areas anywhere across the world for above mentioned reasons and may prove to be one important step towards survival and preservation of avian populations coupled with sustainable agriculture. There is need to work on ornitho-fauna of both traditional and modern allied agricultural sectors so as to develop location/regional specific models for both sustainable agriculture and preservation of avian populations.

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Author's contributions

Tejdeep Kaur Kler planned the study and analyzed the data. Harnoor Kaur Grewal took field observations, compiled and statistically analyzed the data and wrote the 1st draft of the manuscript which was subjected to a critical revision and editing by herself and Tejdeep Kaur Kler. Sukhpreet Kaur Sidhu collected literature and edited the manuscript.

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